HAC Proceeding Docket No. WT 01-309

Contractors Review 1995, Poster P-34

Measurement of ELF Magnetic Fields from GSM Cellular Telephones and Battery Packs

Linde T. and Hansson Mild K.

National Institute for Working Life, P. O. Box 7654, S-907 13 Umeå, Sweden

Introduction 1

Digital GSM cellular telephones transmit on the 900 MHz band (890–915 MHz). Digital information is sent in bursts of 577 µs duration with 217 bursts per second. This pulsed transmitting mode (maximum 2 W peak power) is in turn yielding pulsed currents in the phone and battery pack. These pulsed currents can reach peak values of approximately 1 A and corresponding pulsed magnetic fields are produced.

Methods 1

This study involved two models of digital phones here called unit A and B respectively. The magnetic flux densities were measured one-dimensionally using an Emdex II instrument which gives true rms readings in the range 40–800 Hz. The measurement points were distributed throughout the front of the phone at two distances from the phone casing (1.6 and 3.0 cm).

A calibration check of the Emdex II instrument proved the documentation to be incorrect regarding the frequency response. The filter is steep at the lower cut off frequency with -3 dB at 40 Hz. At the other end the filter falls off slowly from 800 Hz reaching -3 dB at 1.4 kHz. At 2.5 kHz the filter passes -6 dB.

Many magnetic flux meters are not suitable for measurements of this kind. The pulsed microwaves can interfere with the electronics of the instrument and cause erroneous readings.

The Battery Current

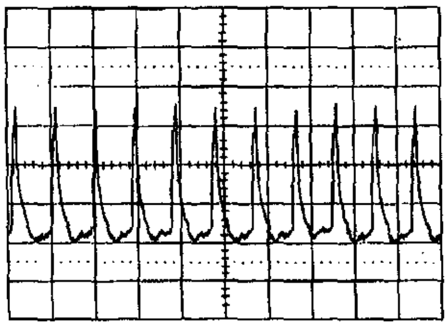

Figure 1. The 217 Hz current was picked up from unit B using a current probe (Tektronix P6021) and displayed on an oscilloscope. The time scale used is 5 ms per division.

The Current Pulse

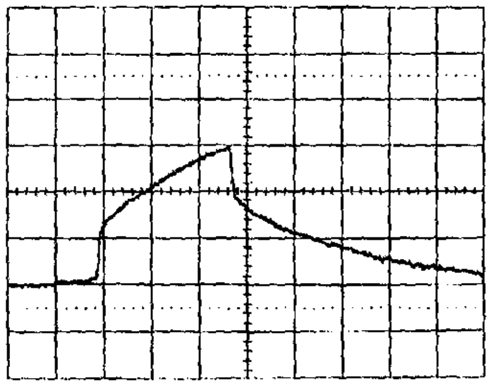

Figure 2. A close up view of the current pulse. The time scale used is 200 μs per division.

Results of the Measurements

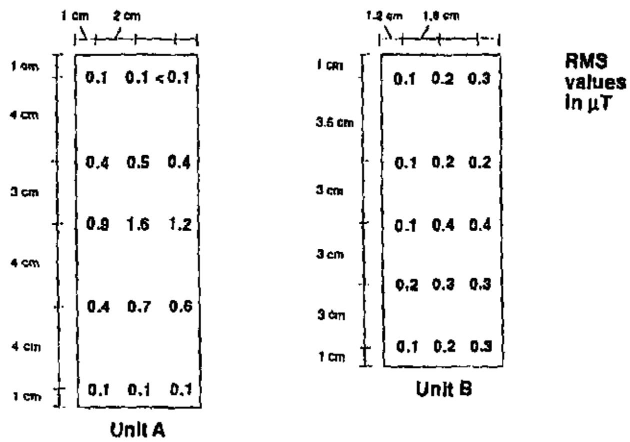

Figure 3. The phones were measured during three different calls and the mean value was calculated at each point. The figures in the picture above refers to the rms value of the magnetic flux density (in μT) at the distance 1.6 cm. For unit A the values dropped on an average 1.4 times as the distance was increased from 1.6 to 3.0 cm. For unit B the corresponding drop was 2.3 times. According to the calibration of the instruments used and a frequency analysis of the recorded current, the rms reading is approximately 90% of the "true" rms value (considering frequencies up to 5 kHz). Since the digital pulse only constitutes 1/8 of the total transmitting time, peak values would reveal additional information of the magnetic field. Peak values would be approximately 2.9 times higher then the rms values in the figure above.

Introduction 2

Battery packs for cellular telephones are in general designed to be compact and light weight, not with low magnetic fields in mind. Unfortunately this has led to battery packs with current loops yielding relatively high magnetic flux densities. A simple rewiring of three commercial battery packs showed that it is possible to greatly reduce the magnetic flux densities with simple means.

Methods 2

This study involved three models of battery packs. The magnetic flux densities were measured using a Bell 640 Incremental Gauss Meter. A resistive load was connected to the batteries and adjusted to yield a DC current of 0.5 A. The magnetic flux density was measured one dimensionally (perpendicular to the plane of the battery packs) at a distance of 1.0 cm from the batteries.

Measuring the Battery Packs

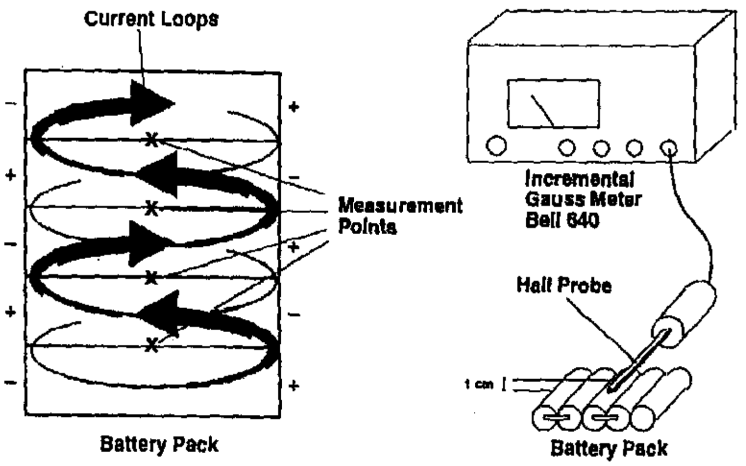

Figure 4. In order to see how a simple rerouting of the wires affected the magnetic flux density the DC magnetic field from the battery packs was measured. The measurement points were distributed according to the above figure at a distance of 1.0 cm from the batteries. The basic idea was to get points in the middle of as well as between the current loops.

Rewired Battery Packs

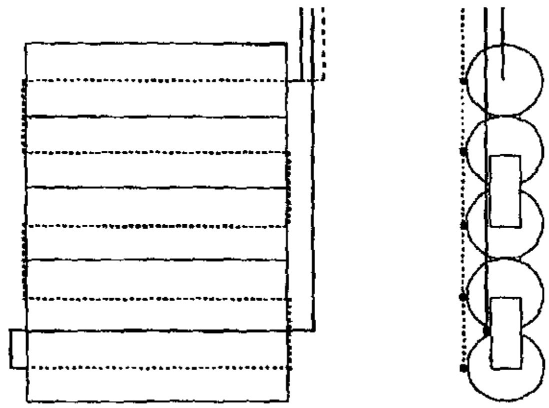

Figure 5. In an attempt to eliminate the effects of the current loops the battery packs were rewired. The new wires follow the current loops hence canceling out much of the magnetic fields emanating from the loops. The above figure shows an example of a rewired battery pack.

Results of the Rewiring

A simple rewiring reduced the magnetic fields from the battery packs by 3–4 times in the middle of a loop and by 8–26 times between the current loops. These figures are not intended to be precise measurements of the magnetic fields from battery pack. Still they show that a lot can be done to reduce the magnetic fields from the battery packs by simple means.

Discussion

Since supply currents in the circuit board and battery pack can reach peak values of approximately 1 A, current loops can generate substantial magnetic fields. A simple rewiring of the battery pack would greatly reduce the magnetic fields.

The highest rms value of the tested phones was 1.6 µT, produced by unit A. According to the calibration this would be approximately 90% of the "true" rms-value, hence the "true" rms-value would be 1.8 µT. This yields a peak value of 5.2 µT.

Arbetslivsinstitutet